Jet Propulsion Laboratory
California Institute of Technology

A Concept for a Joint NASA/ESA Mission for In Situ Exploration of an Ice Giant Planet

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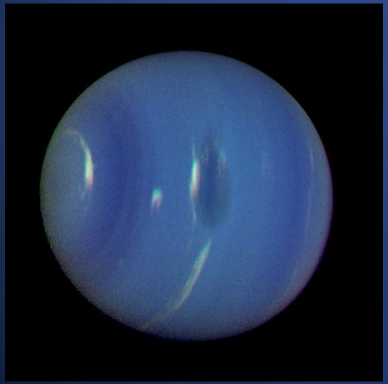
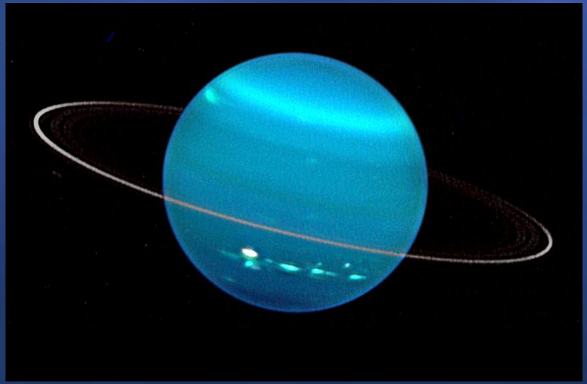
Science Justification for Outer Planet Entry Probes

***Comparative planetology** of well-mixed atmospheres of the outer planets is key to the origin and evolution of the Solar System, and, by extension, extrasolar systems.*

Atreya, S. K. et al., "Multiprobe exploration of the giant planets – Shallow probes," Proceedings of the 3rd International Planetary Probes Workshop, Anavyssos, Greece, 2005.

For all the capabilities of remote sensing, only *in situ* exploration by descent probe(s) can completely reveal the secrets of the deep, well-mixed atmosphere containing pristine materials from the epoch and location of giant planet formation.





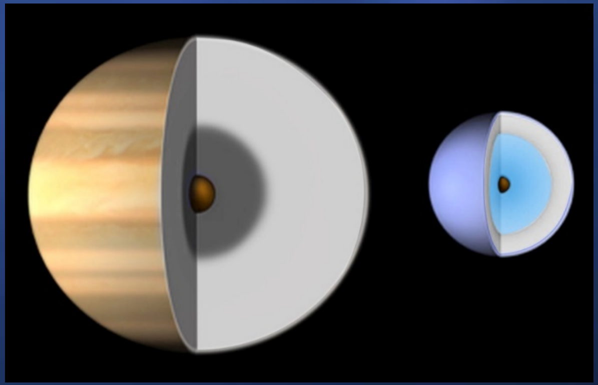


Photo Credits: NASA

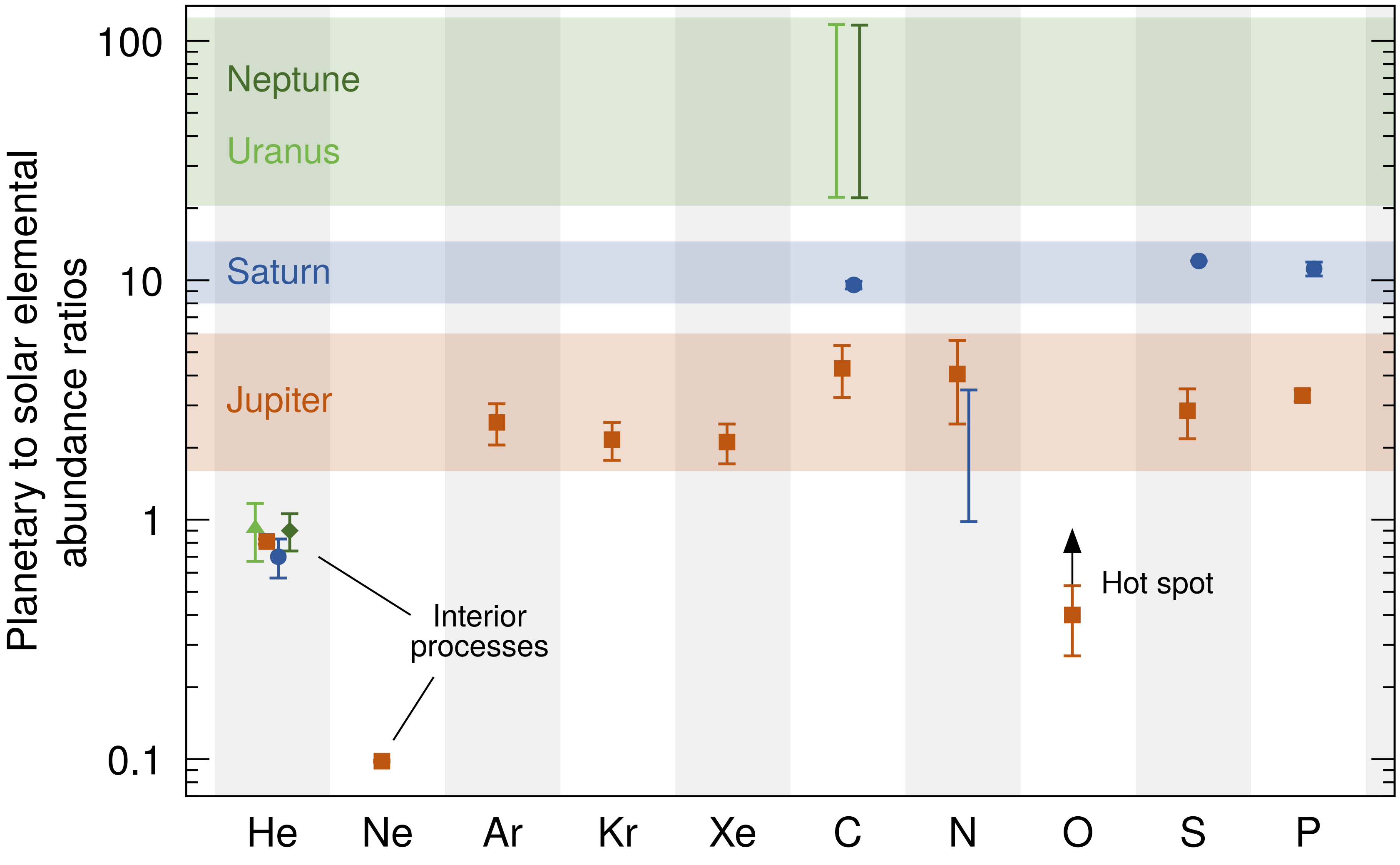
Motivation and Background

- Giant planets have played a significant role in shaping the architecture of the solar system, including the smaller, inner terrestrial planets.
- The efficiency of remote sensing observations has some limitations, especially to study the bulk atmospheric composition. In particular, the measurement of noble gas and helium abundances requires in situ measurements.
- The Galileo probe provided a giant step forward regarding our understanding of Jupiter.
- It remains unknown, however, whether measurements by the Galileo probe are unique to Jupiter or are representative of all gas giants including Saturn, and how the composition, processes, and dynamics of the giant planets are similar to and different from the ice giants.

Key Measurements Needed

- **Bulk composition**: Elemental abundances including O, C, N, S, He, Ne, Ar, Kr, Xe
- **Isotopic ratios**: Noble gas isotopes, D/H, $^{13}C/^{12}C$, $^{15}N/^{14}N$
- **He/H_2 ratio**: For planetary heat balance, interior processes, and thermal history
- **Ortho/Para H_2 ratio:** For thermal structure, and interior processes

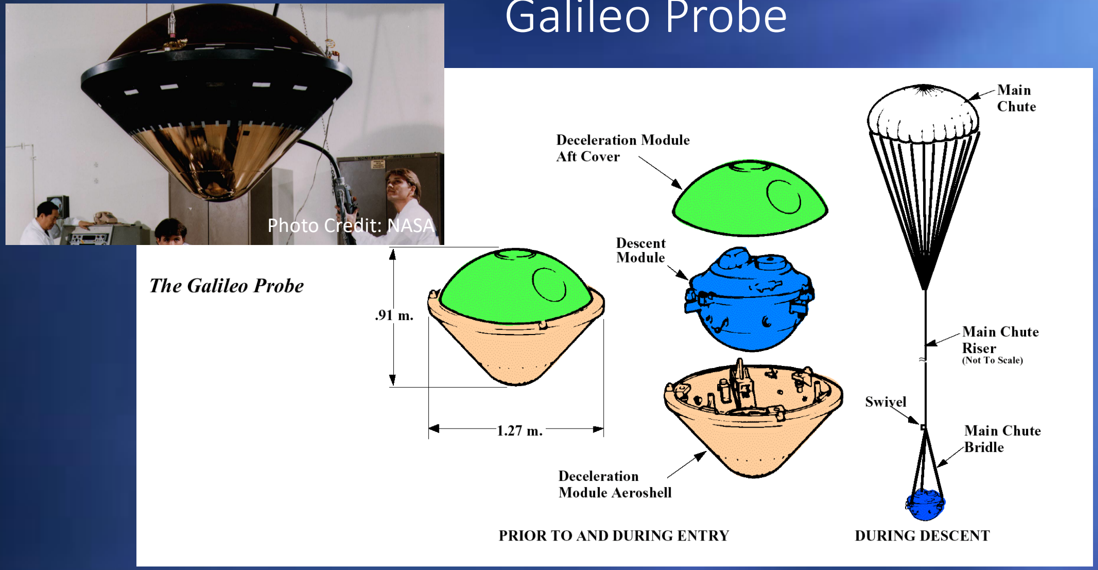
Existing Measurements



Atreya et al. (2018), Mousis et al. (2018)

Heritage: Previous Studies and Previous Missions

Galileo Probe



NASA 1973


NASA TECHNICAL MEMORANDUM

N73-30800
NASA TM X-2824

CASE FILE COPY

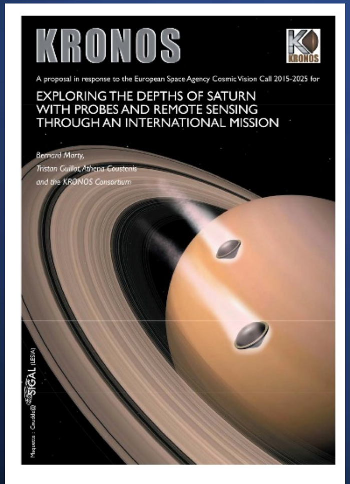
MISSION PLANNING FOR PIONEER SATURN/URANUS ATMOSPHERIC PROBE MISSIONS

by Byron L. Swenson, Edward L. Tindle, and Larry A. Manning

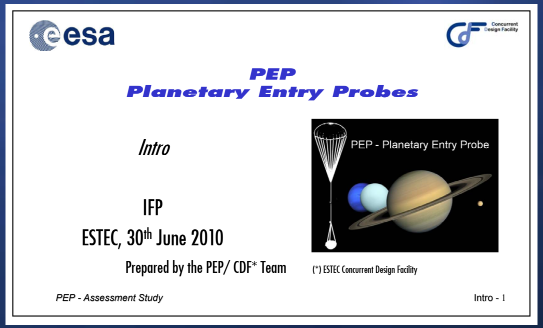
Ames Research Center
Moffett Field, Calif. 94035

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C. • SEPTEMBER 1973

ESA KRONOS Proposal

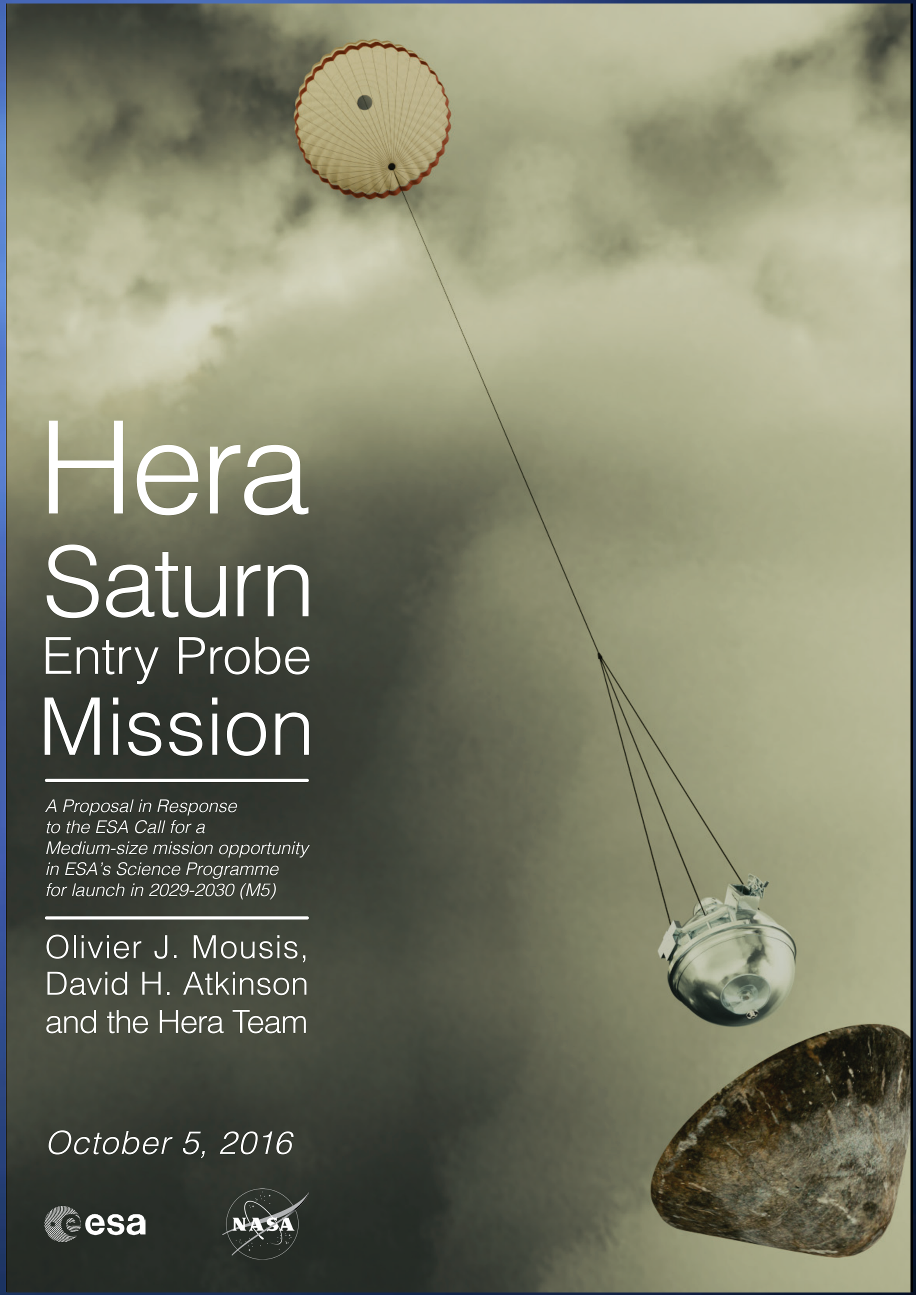


ESA Huygens Probe



ESA PEP Study


SPRITE
Saturn Probe Interior and Atmosphere Explorer
NASA New Frontiers 4
Amy Simon, PI


Hera
Saturn
Entry Probe
Mission
A Proposal in Response
to the ESA Call for a
Medium-size mission opportunity
in ESA's Science Programme
for launch in 2029-2030 (M5)
Olivier J. Mousis,
David H. Atkinson
and the Hera Team
October 5, 2016
esa
NASA

Saturn Entry Probe Potential

for Uranus and Neptune Missions

Thomas R. Spilker, *Jet Propulsion Laboratory / CIT*
David H. Atkinson, *Univ. of Idaho*

9th International Planetary Probes Workshop
Toulouse, France

2012 June 18

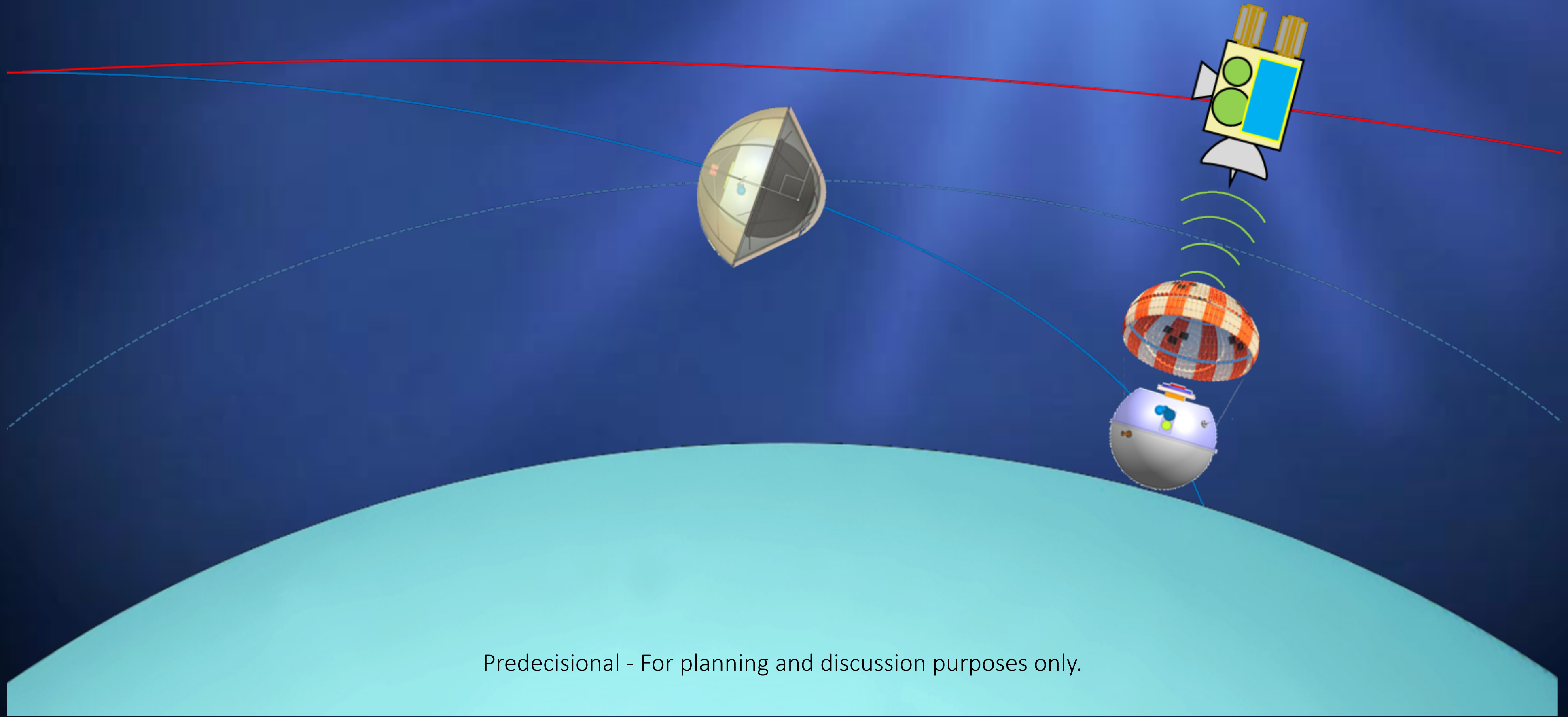
Ice Giant Probe Mission Concept

From Reh, et al. Return to the Ice Giants Pre-Decadal study summary, IPPW-14, 12-16 June, 2017

Release:
- ~60 days prior to entry
- Spin stabilized
- RHUs for coast heating

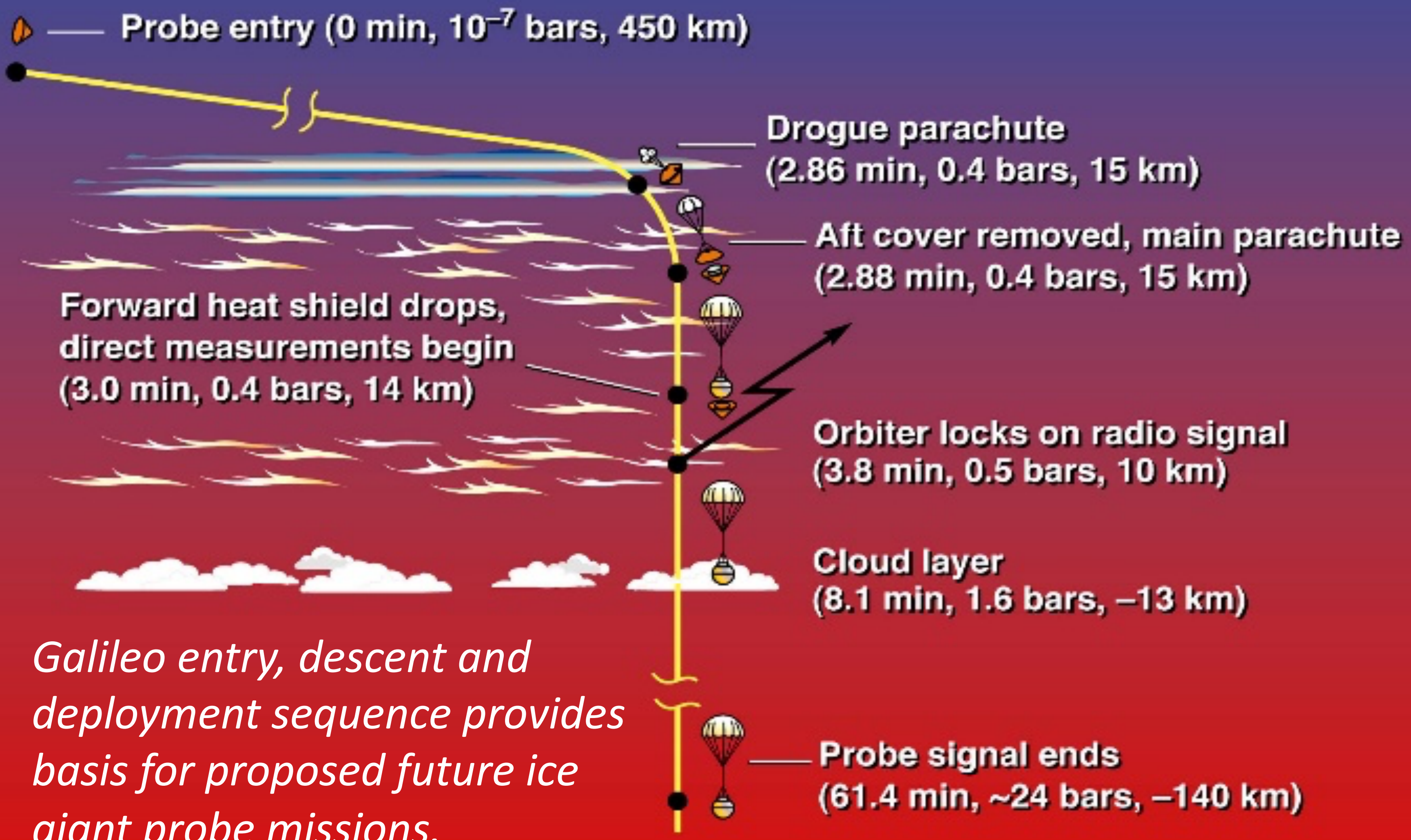
Uranus/Neptune Entry:
Entry V = 23.5/24.1 km/s

Telecomm to Carrier Relay Spacecraft:
Duration: >1 hr
Max Range: <100,000 km



Predecisional - For planning and discussion purposes only.

Galileo Probe Mission



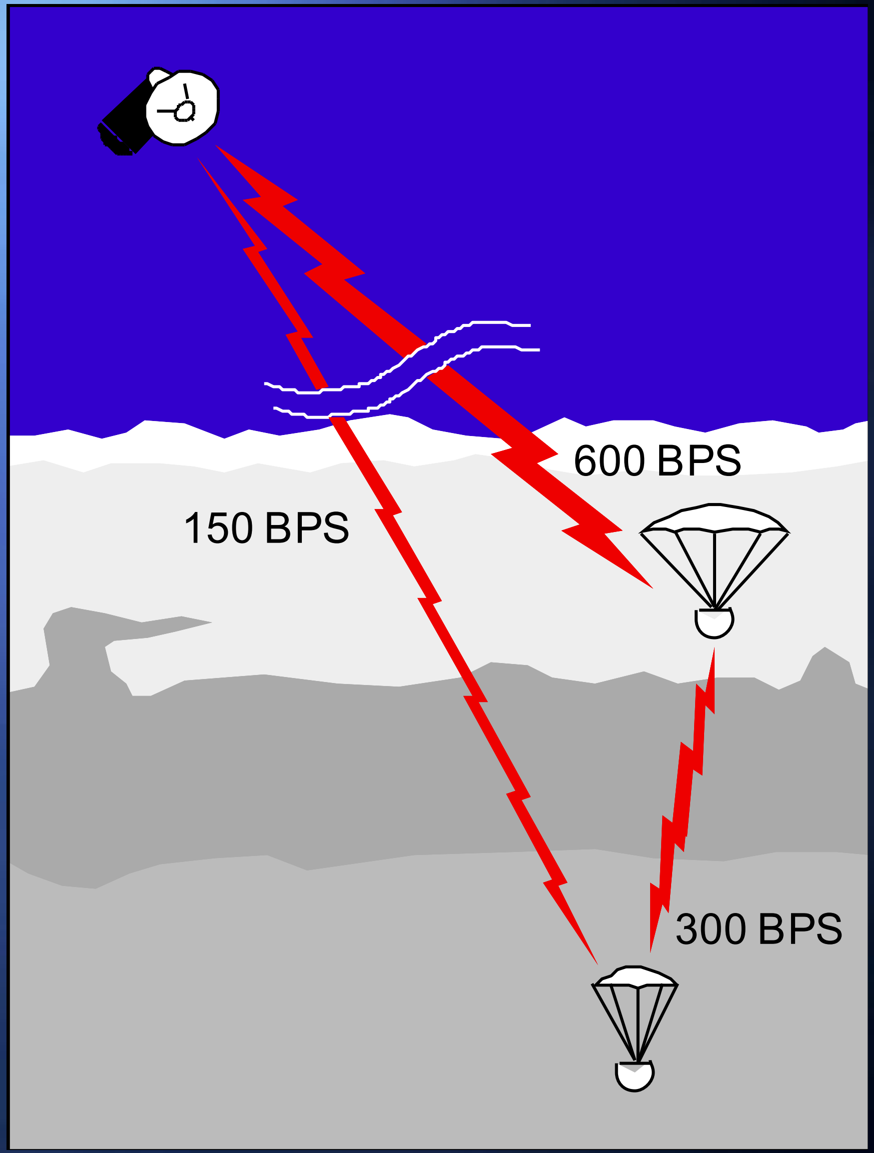
Galileo entry, descent and deployment sequence provides basis for proposed future ice giant probe missions.

Probe Science Payload

Instrument	Measurement
Mass Spectrometer (MS)	Elemental and chemical composition including noble gases and key isotopes
Atmospheric Structure Instrument (ASI)	Pressure and Temperature, Entry and Descent Accelerations → Density
Radio Science Experiment	Atmospheric dynamics: winds and waves; atmospheric absorption → composition
Nephelometer	Cloud structure, aerosol number densities and characteristics
Net Flux Radiometer	Net radiative fluxes: upwelling thermal IR, solar energy
Helium Abundance Detector	Helium Abundance

Deep Probe Telecommunications: Staged Probes

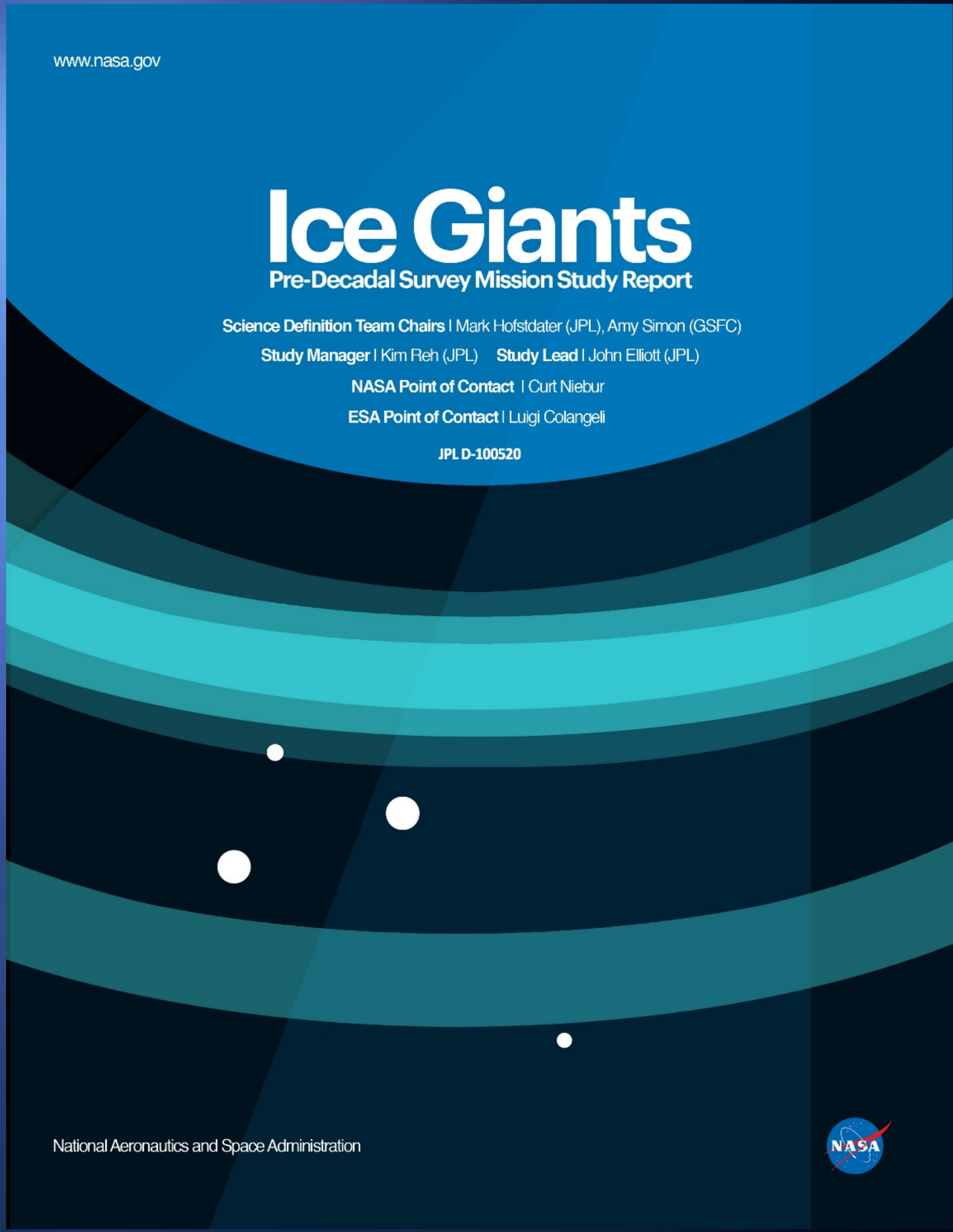
- Outer planet atmospheres primarily H_2/He but with significant radio-absorbing species: NH_3, H_2O.
- At UHF, shallow probes (10-20 bars) remain within relatively "clear" atmosphere → low absorption.
- Communication from deep atmosphere requires transmission through absorbing atmosphere → greatly reduced data throughput.
- Architecture Option: Shallow probe descending slowly releases deep probe for rapid descent → Offers potential to overcome RF opacity that limits deep probe telecomm data rates.



Summary

- The Giant Planets played a significant role in shaping the solar system including the formation and evolution of the terrestrial planets.
- With the exception of in situ measurements of Saturn's atmospheric composition, the Jupiter and Saturn systems have been explored in detail. The last largely unexplored class of planets is the Ice Giants.
- Remote Sensing is a very powerful technique, but is unable to measure essential components of the atmosphere, noble gases and key isotopes in particular.
- The legacy of the Galileo probe mission directly translates to concepts for future planet entry probe missions to Saturn and the ice giants.

> Future ice giant explorations require an in situ element that will draw heavily on the experience of the Galileo probe, and outer planet probe mission concept studies.



How to get involved?

- Students
- Researchers
- Educators

Opportunities at JPL

Dare Might Things

Students Internships

https://www.jpl.nasa.gov/edu/intern/


Congratulations
07/02/2004

Recent Graduates

https://www.jpl.nasa.gov/opportunities/

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Click Column Header to Sort

Requisition ID	Posting Title	Related Academic Majors	Requisition Post Information* : Posted Date
2017-8269	Systems Engineer I	..	4/19/2017
2017-8179	Technical Information Compliance Analyst I	..	3/28/2017
2017-8160	Engineering Undergraduate Student III	Electrical Engineering, Physics, Systems Engineering	3/27/2017
2017-8115	Data Scientist I - Artificial Intelligence Group	Computer Science	3/17/2017
2017-8089	Research Scientist II, Ice Sheet System Model (ISSM)	Earth Sciences	3/22/2017
2017-8059	NASA JPL Software Engineer I	Computer Science, Software Engineering	3/13/2017
2017-8058	NASA JPL Software Engineer II	Computer Science, Information Systems, Software Engineering	3/13/2017
2017-8033	Flight Software Engineer I	Computer Science, Electrical Engineering	3/7/2017
2017-7983	Research Scientist II, Geophysics and Planetary Geosciences Group	..	2/28/2017
2017-7963	Planetary Protection Engineer I	..	2/27/2017
2017-7945	Resource Analyst I	Accounting, Business Administration	3/2/2017
2017-7920	Engineering Applications Software Engineer II	Computer Science, Mathematics, Systems Engineering	4/18/2017
2017-7918	NASA JPL Software Year-Round Internship	Computer Science, Mathematics, Systems Engineering	4/18/2017
2017-7896	Parts Engineer I	Electrical Engineering	2/6/2017
2017-7820	Scientist II, WFIRST Coronagraph Scientist/Instrumentalist	..	1/19/2017
2017-7786	Subcontract Manager 1, Commercial Subcontracts & Strategic Sourcing Section	Accounting, Business Administration, Finance, Supply Chain	1/25/2017
2016-7680	Optical Engineer - New Grad	Computer Science, Electrical Engineering, Optical Engineering, Systems Engineering	2/22/2017
2016-7523	Software Engineer II - Data Services Group (397G)	Computer Science, Software Engineering	4/7/2017
2016-7454	Thermal Engineer I	Mechanical Engineering	10/11/2016
2016-7014	Flight Software Engineer II - Artificial Intelligence	..	10/12/2016

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Postdoctoral Opportunities

NASA Postdoctoral Program
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JPL Postdoctoral Associate Program

https://www.jpl.nasa.gov/opportunities/

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https://scienceandtechnology.jpl.nasa.gov/opportunities

- Visiting Scholars Program
- Faculty Programs
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- Postdoctoral Programs

Summer Faculty Fellowship Program
https://www.jpl.nasa.gov/edu/intern/apply/jpl-faculty-research-program/

Senior Research Postdoctoral Program
https://postdocs.jpl.nasa.gov/programs/npp/seniorfellows/

JPL Opportunities
Teachers & Students

Activities, Resources, Workshops, Programs, Lesson Plans

https://www.jpl.nasa.gov/edu/teach/

Activities, Toolkits, Contests

https://www.jpl.nasa.gov/edu/learn/

For questions on opportunities for
students, researchers, and educators, please contact

West Virginia Space Grant / NASA EPSCoR: http://www.wvspacegrant.org/

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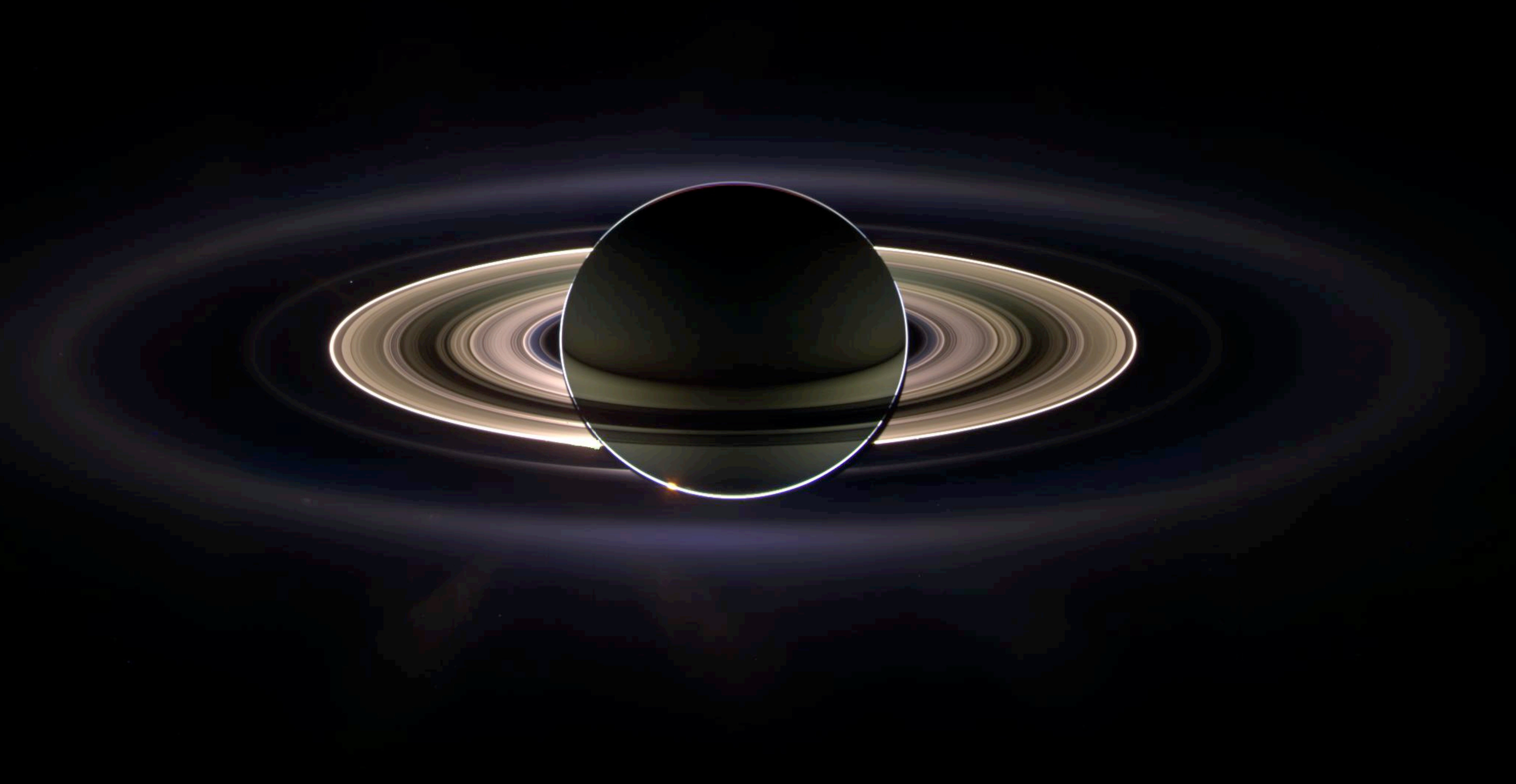

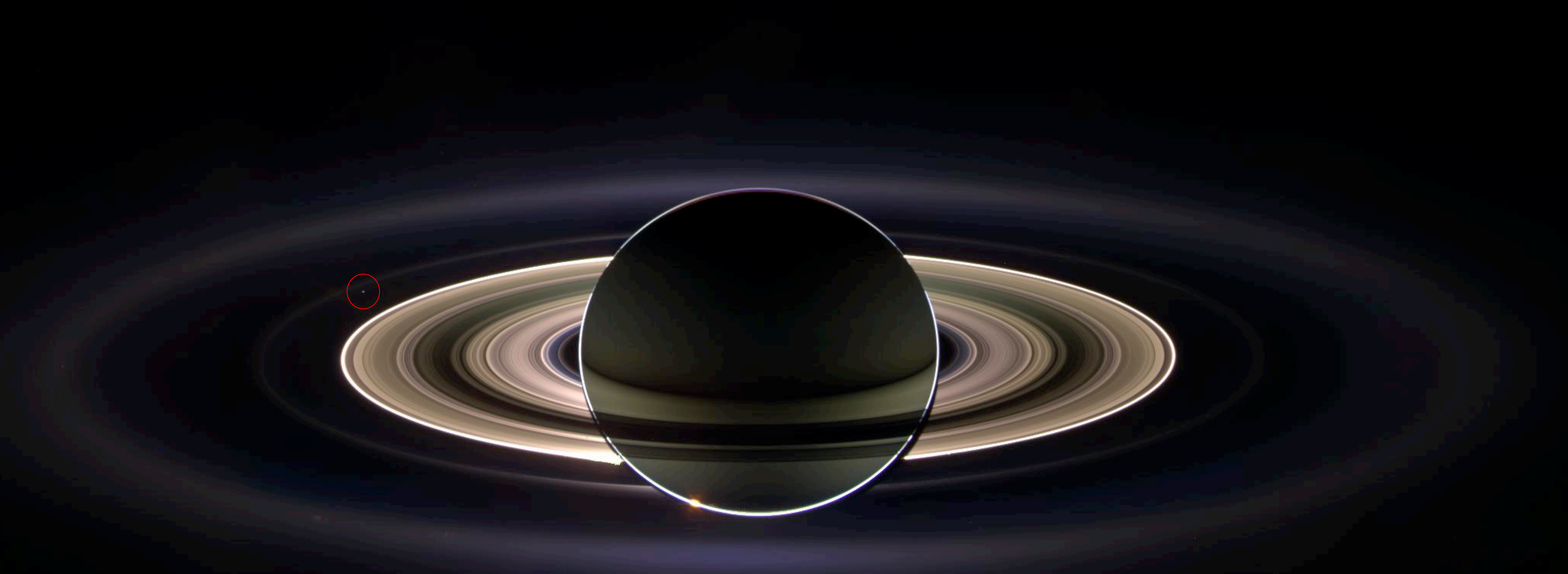

"The Earth is the cradle of the mind,
but one cannot live in the cradle forever."

- K. E. Tsiolkovsky